

# Lower Carbon Concrete

## Covered materials and products

Concrete for use in buildings as well as horizontal (roadways and infrastructure) <sup>(1)</sup> including modular units such as Concrete Masonry Units (CMU) and Concrete Brick.

## Goal

To inform through this guidance document how Design Professionals (Architects or Engineers of Record) specify concrete, in a way that builds upon current market capabilities, practices, and available materials, so that we dramatically reduce the embodied carbon burden of the entire building industry.

## Background

To achieve the GHG reduction goals of the Climate Leadership and Community Protection Act the State needs to reduce the embodied carbon in our built environment. Concrete includes use of cement which yields approximately 0.9 pounds of carbon emission equivalents (CO<sub>2</sub>e) for each pound of cement produced.

## Definitions

**Aggregates:** the gravel, sand, or recycled and sometimes decorative materials, at specified sizes, that are held by the cured paste in concrete.

**CMU:** Concrete Masonry Units are standard sized rectangular blocks made from concrete in off-site production, typically using molds or cutting machines. Mix includes cement and aggregates such as sand or gravel and may include add-mixtures or decorative pigments or aggregates.

**Embodied Carbon<sup>[2]</sup>:** The amount of CO<sub>2</sub> equivalence (CO<sub>2</sub>e) in mining, manufacturing/processes, and assembly of a product in what is referred to as “Stage A1-A3” of a Life Cycle Assessment, also known as the up-front embodied carbon emissions.

**GGP (Ground-Glass Pozzolans):** Note that the alkali-silica reaction (ASR) is mitigated with finely ground glass powder.

**Local Aggregates:** Locally sourced stone at requisite size and characteristics for use in the concrete mix, reducing embodied carbon through reduction in transit weight and volume.

**Matrix:** the paste and aggregate combination that is the concrete mix.

**Paste (also Binder):** the slurry of cement, SCM, and water that cures to hold the aggregates in concrete.

**PLC (Portland-Limestone Cement):** a slightly modified version of Portland cement that improves the environmental footprint; now described in ASTM and AASHTO specifications.

**Recycled Concrete Aggregates and Coarse Crushed Concrete Aggregates (RCA and CCA):** deconstructed concrete crushed on-site or off, intended for re-use in projects, typically as fill. RCA is not called for in the listed approaches.

**Strength test:** A test of poured units, performed most often at 28-days of curing, to confirm the concrete has achieved the required strength.

**Supplementary Cementitious Materials (SCM) and Pozzolans:** materials resulting from another manufacturing process or waste stream that may be processed and used to replace portions or all cement in concrete. SCMs chemically react to provide cementitious properties and enhance concrete strength and durability, and include fly ash, slag cement, silica fume, natural pozzolans, or GGP. These materials should comply with relevant specifications.

### **Standard Setting and Certifying Programs**

**EPDs<sup>[3]</sup>:** Type III declaration that "quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function." The EPD methodology is based on the Life Cycle Assessment (LCA) tool that follows ISO series 14040 (from ISO 14025).

### **Specifications**

Affected entities shall, to the maximum extent practicable, procure lower-carbon concrete through the following considerations while meeting strength and other performance requirements as designed by the Design Professional in the Technical Specifications for the project:

#### **Batch Plant Ready-mix concrete delivered to jobsite:**

##### **1. Provide an EPD where available.**

- In order of preference, batch-specific, regional, and then industry average EPDs.
- In instances where no EPD is available, we have provided the listing below to inform SCM selections. Stated as lb. CO<sub>2</sub> per unit lb. material, industry average.
  - Cement – 0.9060
  - Slag – 0.0210
  - Virgin Coarse Aggregate – 0.0459
  - Sand - 0.0139
  - Fly Ash – 0.0000
  - Silica Fume – 0.0000
  - CCCA – 0.0212
  - PLC – 0.8154 - 0.8426

##### **2. Set Cement Content limits.**

- Mix designs are limited to a maximum Portland cement content of 400 pounds per cubic yard.
  - This does not include sidewalks, slabs on grade, or any application that requires a final finish.
- Mix designs are limited to a maximum Portland cement content of 300 pounds per cubic yard for mass concrete and all concrete applications below grade and against earth, or below grade and confined concrete such as concrete fill within steel pipe piles.
  - The design may also limit the cement content to 300 pounds per cubic yard for other applications, provided that the performance requirements established by the Design Professional are met.

**3. Achieve Additional Cement use reduction with inclusion of pozzolans.**

- 30% minimum total SCM (including fly ash, slag, silica fume, and/or metakaolin) by total weight of all cementitious materials, unless otherwise shown on the Contract Drawings.
- Micro ground-glass pozzolans are acceptable for use in alignment with ASTM C1866.

**4. Cement use reduction through reduction in percentage of paste.**

- Use of blended aggregates when available.
  - The nominal maximum size of coarse aggregate used shall be the largest size aggregate but should not be larger than (1) one-fifth the narrowest dimension between sides of forms or (2) one-third the depth of slabs or (3) three-quarters the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, or prestressing tendons or ducts.
  - Coarse Aggregate (Normal Weight Concrete): Conforming to ASTM C 33, ASTM C 227, and ASTM C 535 with a maximum percentage of wear of 40 percent, and ASTM C 88 with a magnesium sulfate loss of not more than 12 percent for a five-cycle test period.
  - For full depth pavement concrete the combined aggregate volume shall be a minimum of 70 percent. The combined gradation of the fine and coarse aggregate shall conform to the following table, when tested in accordance with ASTM C 136:

	For Pavement 10 Inches or Greater in Thickness		For Pavement Less Than 10 Inches in Thickness	
Sieve Size % Passing	Min.	Max.	Min.	Max.
2-1/2"	100			
2"	90	98	100	
1-1/2"	76	88	89	98
1"	67	79	74	86
3/4"	65	77	64	76
3/8"	48	60	48	60
No. 4	30	42	30	42
No. 8	27	37	27	37
No. 16	20	30	20	30
No. 30	16	22	16	22
No. 50	4	10	4	10
No. 100	0	4	0	4

**CMU and Concrete Bricks:**

1. Provide Industry EPDs when available.
2. Consider reduced-profile web design per ASTM C-90.
3. Reduce cement content using guidance above.
  - This may require additional additives to affect a cure-time that allows release from any molds with the planned pre-cast timeframe.

**Entities are encouraged to consider the following (no order of priority):**

- *Maximize SCM percentage while still meeting performance requirements*
- *Extend cure-time to 56 days for designed strength*
- *Consider sourcing from an Energy Star Certified Industrial Plant (note there are currently none listed in NY state)*
- *Expose structural concrete as finish material to reduce additional material layers*
- *Ensure “right-sized” structural elements*
- *Use alternate structural components (e.g., mass timber)*
- *Apply Carbon Capture, Utilization, and/or Storage (CCUS) in tandem with additional cement reduction*
- *Include anticipated life of project in defining embodied carbon goals*

**Take-Back/ Recycling**

Affected entities are encouraged to:

- Limit “attic stock” when purchasing modular units.
- Develop a plan for a design and responsible on-site use of any overage from concrete mixer trucks or on-site mixing processes

**Disposal**

If materials are being transferred for disposition, a record of each disposition shall be retained by the affected entity. Documentation shall be provided to the affected entity demonstrating that these products have been disposed of or beneficially reused in an environmentally sound manner in compliance with applicable local, state, and federal laws.

Related to pre-cast units, such as CMU, the contractor or disposing party shall provide assurance to the affected entity that all exports of used materials collected for reuse, recycling, or disposal will be in compliance with the laws of the importing country.

**Packaging**

Packaging shall comply with Environmental Conservation Law section 37-0205. Packaging shall not contain inks, dyes, pigments, adhesives, stabilizers, or any other additives to which any lead, cadmium, mercury, or hexavalent chromium is intentionally added or contain incidental concentrations of lead, cadmium, mercury or hexavalent chromium which together are greater than 100 parts per million by weight (0.01%).

New York State encourages affected entities to adopt the following:

- The use of bulk packaging.
- The use of reusable packaging.
- The use of innovative packaging that reduces the weight of packaging, reduces packaging waste, or utilizes packaging that is a component of the product.
- That all packaging remains the property of the supplier and not become the property of the affected state entity under any circumstance or condition. The vendor shall certify that the packaging material will be reused, recycled, or composted, and managed in compliance with applicable local, state, and federal laws.
- Packaging that maximizes recycled content and/or meets or exceeds the minimum post-consumer content level for packaging in the U.S. Environmental Protection Agency Comprehensive Procurement Guidelines.
- Packaging that is recyclable or compostable.

### **End Notes**

1 – A highly detailed technical specification on concrete, including a broader array of applications, is available through the exceptional work of the **Port Authority of NY/NJ**. Their spec has informed this effort.

2 - Widely recognized procedures for conducting LCAs are included in the 14000 series of environmental management standards of the International Organization for Standardization (ISO). Note specifically ISO 14040 and ISO 14044.

3 - Additional information on EPDs, from **Port Authority of NY/NJ**.

*Environmental Product Declaration (EPD):* An independently verified report based on life-cycle assessment studies that have been conducted according to a set of common rules for each product category and that have been peer reviewed.

Product-Specific Declaration: An EPD for a product with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that has at least a cradle to gate scope.

Industry-Wide (Generic) EPD: An EPD for a product with a third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the EPD program operator, and in which the EPD conforms to ISO 14025, 14040, 14044, and either EN 15804 or ISO 21930, and has at least a cradle to gate scope.

Product-Specific Type III EPD: An EPD for a product with a third-party certification, including external verification, in which the manufacturer is explicitly recognized by the EPD program operator, and in which the EPD conforms to ISO 14025, 14040, 14044, and either EN 15804 or ISO 21930, and has at least a cradle to gate scope.